Ordering number: EN1272E




Monolithic Linear IC

# LA1135, 1135M

## AM Tuner System for Car Radios and Home Stereos

## Overview

The LA1135 is a high-performance AM electronic tuner IC that is greatly improved in cross modulation characteristics. It is especially suited for use in car radio and home stereo (antenna: loop) applications.

## Functions

- MIX
- OSC (with ALC)
- IF amplifier
- Detector
- AGC (normal)
- RF wide-band AGC
- Auto search stop signal (signal meter output)
- Local oscillation buffer output
- Others

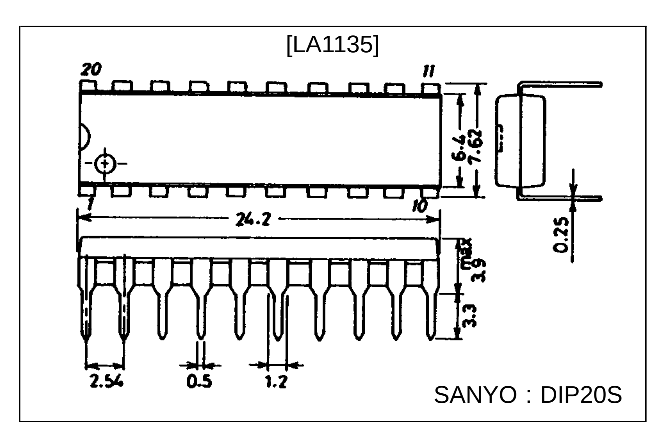
## Features

- Excellent cross modulation characteristics: Meets the requirements for preventing not only adjacent-channel interference but also interference caused by all channels within broadcast band.
- Narrow-band signal meter output: Usable as auto search stop signal. Has linearity up to 80 dBμ.
- Local oscillation buffer output: Facilitates designing of electronic tuner system, frequency display, etc.
- OSC (with ALC): Improves tracking error because oscillation output is stabilized at a low level (380 mVrms) for varactor diode.
- MIX: Double-balanced differential MIX meeting the requirements for preventing spurious interference, IF interference.
- Good characteristics at high input: 130 dBμ input $f_m$ = 400 Hz 80% mod THD = 0.4% typ
- Low noise: Good S/N at medium input (56 dB typ)
- Usable sensitivity: (S/N = 20 dB input): 25 dBμ (2SK315 $I_{DSS}$ = 11mA)
- $V_{CC}$ variation compensation: Less variation in gain, distortion: 8 to 12 V
- Reduced pop noise: Capable of reducing pop noise at the time of $V_{CC}$ ON, mode select by adjusting AGC time constant.

## Package Dimensions

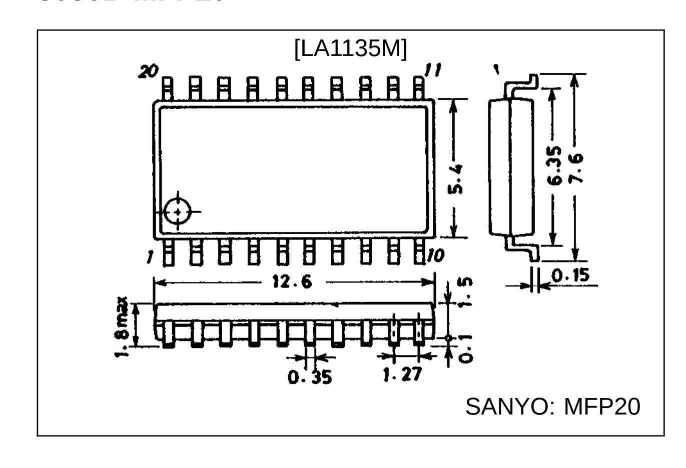
unit : mm

**3021B-DIP20S**




unit : mm

**3036B-MFP20**



# Specifications

## Maximum Ratings at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Maximum supply voltage | $V_{CC}$ max | Pins 8, 14 | 16 | V |
| Output voltage | $V_O$ | Pins 7, 10 | 24 | V |
| Input voltage | $V_{IN}$ | Pin 6 | 5.6 | V |
| Current drain | $I_{CC}$ | Pins 7 + 8 + 10 + 14 | 41 | mA |
| Flow-out current | $I_{18}$ | Pin 18 | 2 | mA |
| | $I_{20}$ | Pin 20 | 2 | mA |
| Allowable power dissipation | Pd max | LA1135 | 730 | mW |
| | | LA1135M Ta ≦ 60°C, with PCB | 660 | mW |
| Operating temperature | Topr | LA1135 | –20 to +70 | °C |
| | | LA1135M | –40 to +80 | °C |
| Storage temperature | Tstg | | –40 to +125 | °C |

## Operating Conditions at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Recommended supply voltage | $V_{CC}$ | | 8 | V |
| Operating supply voltage range | $V_{CC}$ op | | 7.5 to 12 | V |

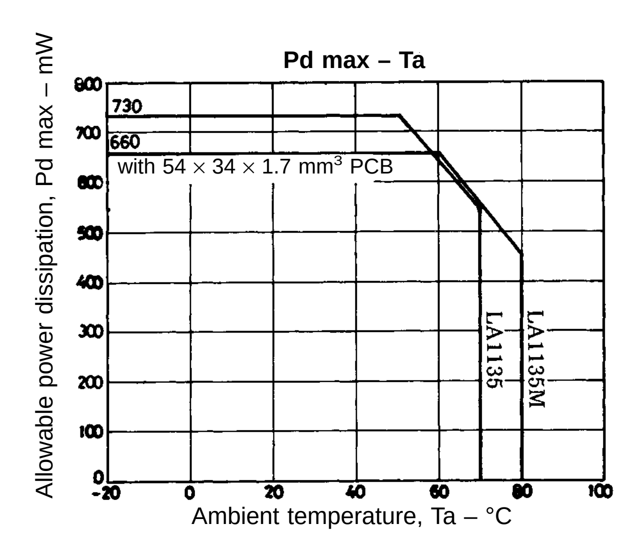
## Operating Characteristics at Ta = 25°C, $V_{CC}$ = 8 V, $f_r$ = 1 MHz, $f_m$ = 400 Hz, See specified Test Circuit.

| Parameter | Symbol | Conditions | min | typ | max | Unit |
|---|---|---|---|---|---|---|
| Current drain | $I_{CC}1$ | Quiescent | 13.5 | 22.5 | 32.5 | mA |
| | $I_{CC}2$ | 130 dBµ input | 20.0 | 30.0 | 41.0 | mA |
| Detection output | $V_O1$ | 16 dBµ input, 30% mod | –29.0 | –25.0 | –21.0 | dBm |
| | $V_O2$ | 74 dBµ input, 30% mod | –15.0 | –12.0 | –9.0 | dBm |
| Signal-to-noise ratio | S/N | 74 dBµ input, 30% mod | 51.0 | 56.0 | | dB |
| Total harmonic distortion | THD1 | 74 dBµ input, 30% mod | | 0.3 | 1.0 | % |
| | THD2 | 74 dBµ input, 80% mod | | 0.3 | 1.0 | % |
| | THD3 | 130 dBµ input, 80% mod | | 0.4 | 2.0 | % |
| Signal meter output | $V_{SM}1$ | Quiescent | | 0 | 0.3 | V |
| | $V_{SM}2$ | 130 dBµ input | 3.5 | 5.0 | 7.5 | V |
| Input at signal meter output 1 V | $V_{IN}1$ | $V_{SM}$ = 1 V | 18.0 | 24.0 | 30.0 | dBµ |
| Local oscillation buffer output | $V_{OSC}$ BUF | | 320 | 380 | | mVrms |

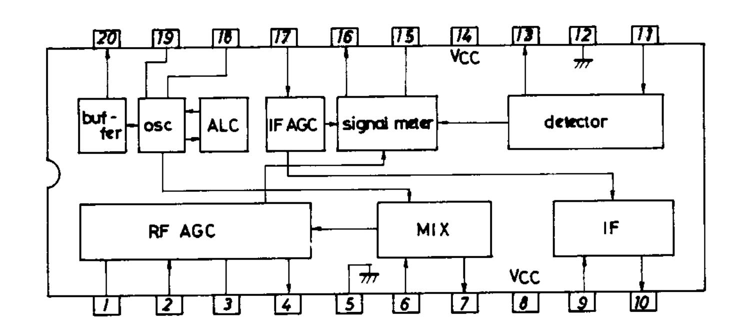
## Reference Characteristics

| Parameter | Symbol | Conditions | typ | Unit |
|---|---|---|---|---|
| Usable sensitivity | Q.S. | Input at S/N = 20 dB<br>(2SK315 $I_{DDS}$ = 11 mA) | 25.0 | dBμ |
| Wide-band AGC<br>ON-state input | | Reception 1.0 MHz quiescent<br>Interference 1.4 MHz non-mod<br>at input for AMT.D. ON | 82.0 | dBμ |
| Detection output variation | $\Delta V_O$ | Input 74 dBμ → 130 dBμ | 0.2 | dB |
| Local oscillation variation within broadcast band | $\Delta V_{OSC}$ | $V_{OSC}L - V_{OSC}H$ | 15 | mVrms |
| Signal meter band * | $V_{SM\text{-}BW1}$ | 74 dBμ input, frequency at which output is reduced to 1/2 | ±1.5 | kHz |
| | $V_{SM\text{-}BW2}$ | 74 dBμ input, frequency at which output is reduced to 1/10 | –4.5/+7 | kHz |
| Selectivity | | 30 % mod ±10 kHz * | 43 | dB |
| IF interference | IF. R. | $f_r$ = 600 kHz * | 77.5 | dB |
| Image frequency interference | IM. R. | $f_r$ = 1400 kHz * | 52.0<br>(63.0) | dB |

Note: *: Wide-band AGC OFF
( ): See circuit on page 7.




## Equivalent Circuit Block Diagram



## Test Circuit 1

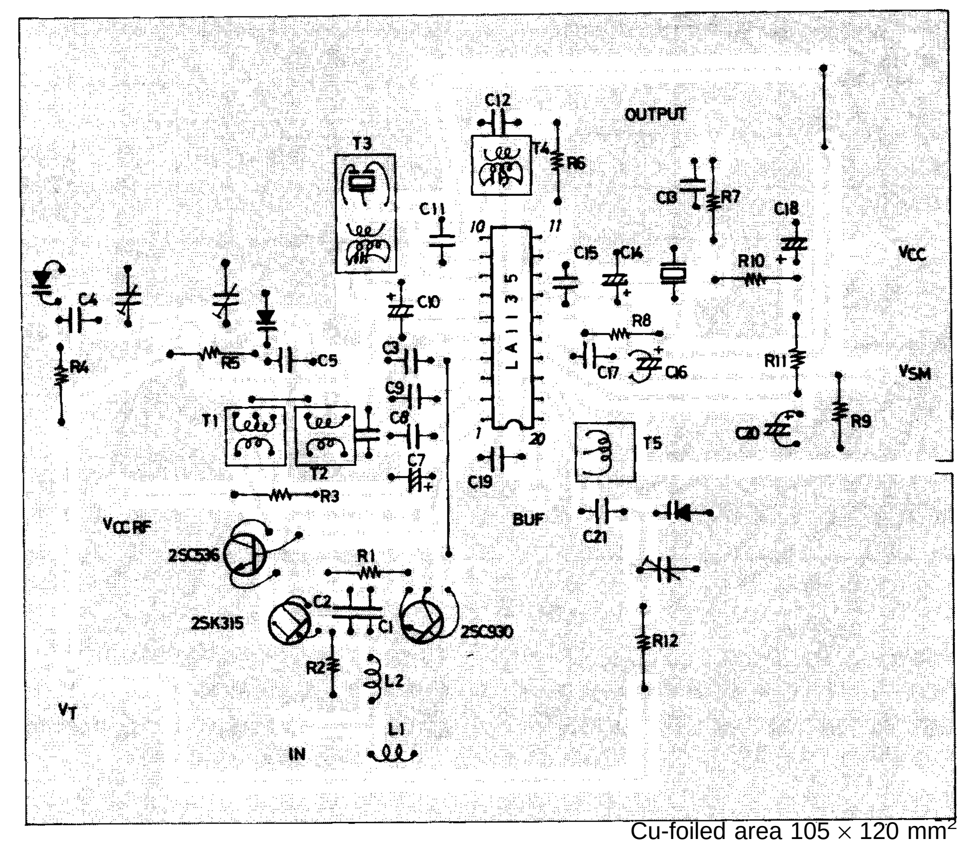
$V_{CC}$ = 8 V, $f_r$ = 1 MHz, $f_m$ = 400 Hz

Unit (resistance: Ω, capacitance: F)

| Varactor diode | SVC321 | (Sanyo) |
|---|---|---|
| Narrow-band filter | BFU450CN | (Murata) |

| Coil | | |
|---|---|---|
| T1 | YT-30020 | (Mitsumi) |
| T2 | YT-30018 | (Mitsumi) |
| T3 | CFMA-027 | (Toko) |
| T4 | YT-30007 | (Mitsumi) |
| T5 | YT-30008 | (Mitsumi) |

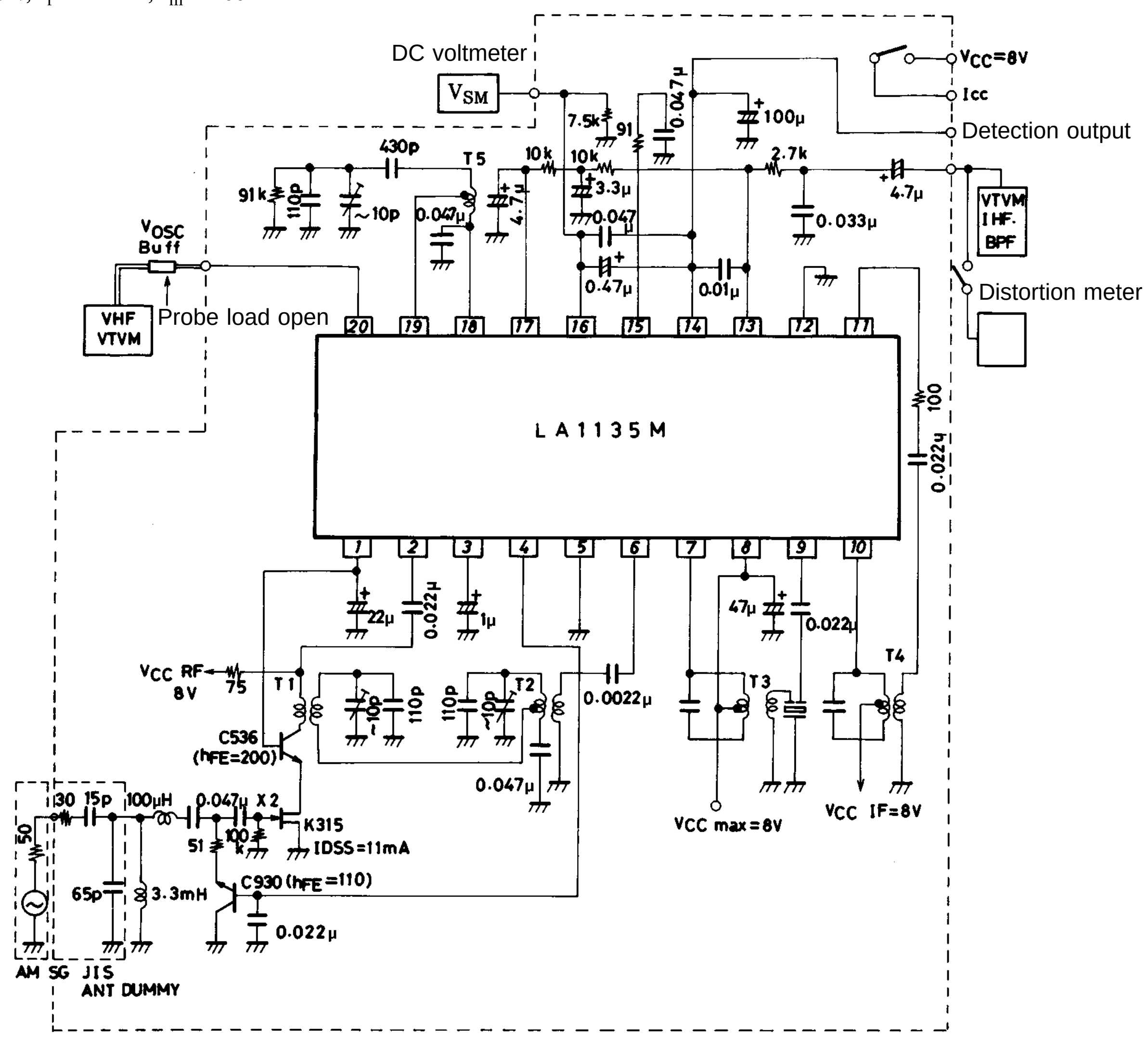
## Sample Printed Circuit Pattern




Cu-foiled area 105 × 120 mm²

## Test Circuit 2

$V_{CC}$ = 8 V, $f_r$ = 1 MHz, $f_m$ = 400 Hz




Unit (resistance: Ω, capacitance: F)

| Coil | | |
|---|---|---|
| T1 | YT-30202 | (Mitsumi) |
| T2 | YT-30018 | (Mitsumi) |
| T3 | CFMA-021A | (Toko) |
| T4 | YT-30007 | (Mitsumi) |
| T5 | YT-30008 | (Mitsumi) |

| | | |
|---|---|---|
| Varactor diode | SVC321 | (Sanyo) |
| Narrow-band filter | BFU450CN | (Murata) |

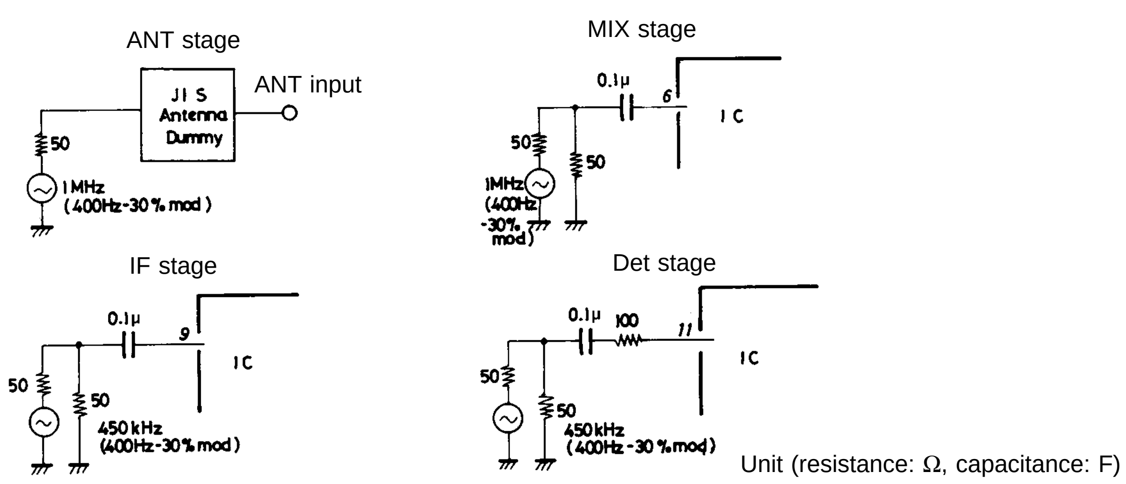
## Proper cares in using IC

1. Bias condition: RF $V_{CC} \leqq$ IF $V_{CC}$
2. Avoid coupling between the antenna tuning circuit and the local oscillation.
3. Connect detection capacitor C15 across pins 13 (output) and 14 ($V_{CC}$) so that no leakage of the IF signal to the GND line occurs. (If connected to GND, the tweet and the usable sensitivity may get worse.) Radiation from C15 may cause harmonics in the IF signal to return to the RF stage, thereby leading to more tweet interference. So, connect C15 as close to pins 13, 14 as possible. Consider the direction of the capacitor and separate it from the ANT circuit.
4. For R9, use a semifixed resistor with $V_{SM}$ considered.
5. When designing the coils, consider the following conditions.
   Shown below is the input level at each pin at which the detection output at $f_m$ = 400 Hz 30% mod becomes –25 dB.

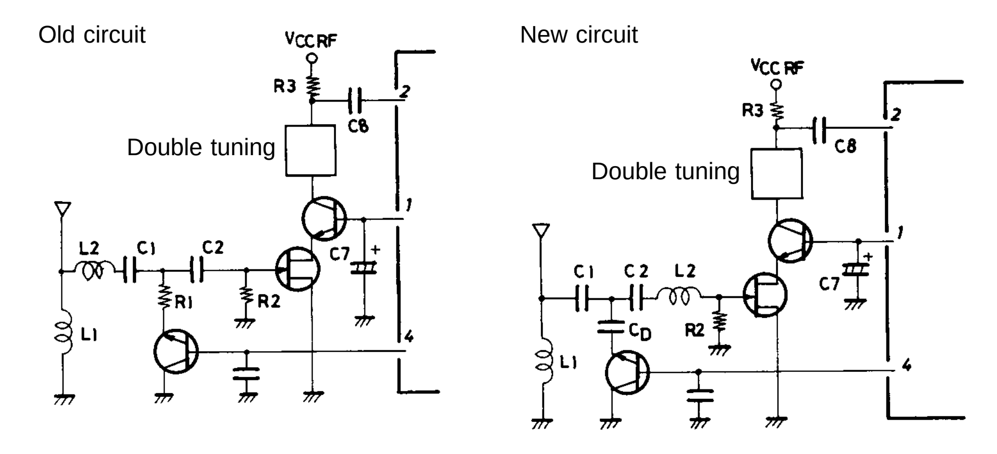
| ANT | MIX | IF | Det |
|---|---|---|---|
| 16.0 | 28.0 | 45.0 | 61.0 |

(dBμ)

**How to apply input to each stage**




6. ANT damping
   To make the ANT damping constant within the receiving band, change the application circuit as shown below.




Measures

Replace R1 with $C_D$.

$C_D$ (2000 pF to 3000 pF or thereabouts)

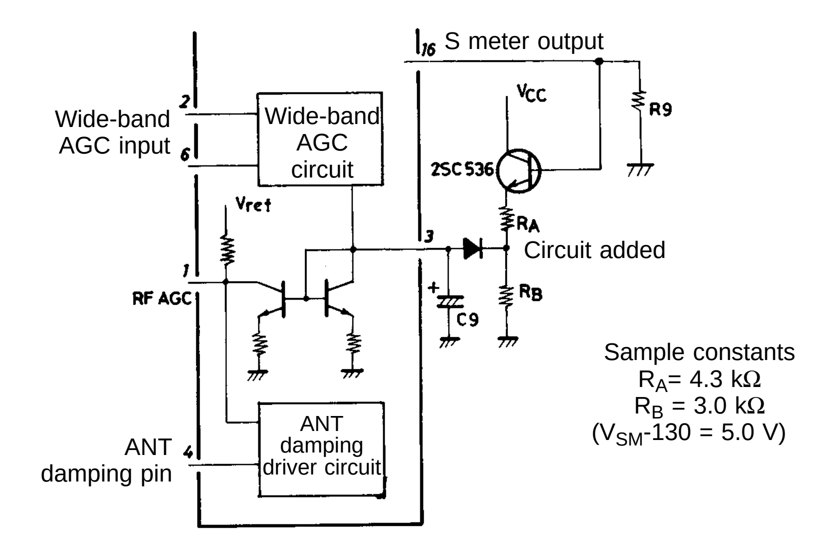
Relocate L2.

Damping (600 kHz to 1400 kHz) Old circuit –15 dB
New circuit –4 dB

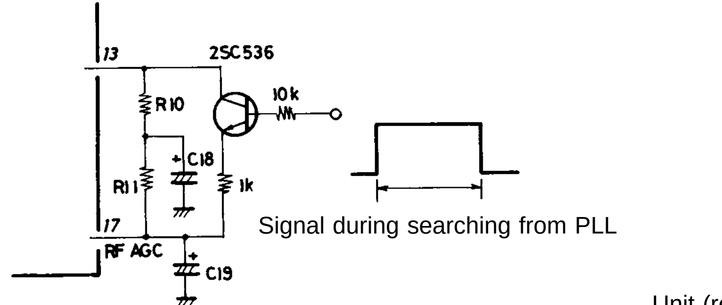
7. Meaning of L2
   If the RF stage is double-tunned, the difference in sensitivity within the RF band almost disappears, but an antireasonance point of approximately 20 MHz appears, thereby leading to worse spurious characteristics. So, L2 is used to remove the SW band.

8. Wide-band AGC
   This IC contains 2-channel wide-band AGC. Pin 6 detects an undesired signal within the RF band and wide-band AGC is applied. This detection sensitivity is determined inside the IC. Pin 2 detects an undesired signal outside the RF band. This detection sensitivity is determined by R3. When 1 mVrms (f = 1 MHz) signal is applied to pin 2, AGC operates.

9. Measures against suppression of sensitivity
   In the AGC circuit of the test circuit the presence of an undesired signal of high strength within the receiving band may cause the desired signal to be suppressed when the desired signal is low or medium in strength. Shown below is the circuit configuration where the necessary measures are taken against this suppression.




10. Transient response of S meter output at search, stop mode
    The circuit configuration shown below is available to stabilize the transient response of the S meter output at the search, stop mode.

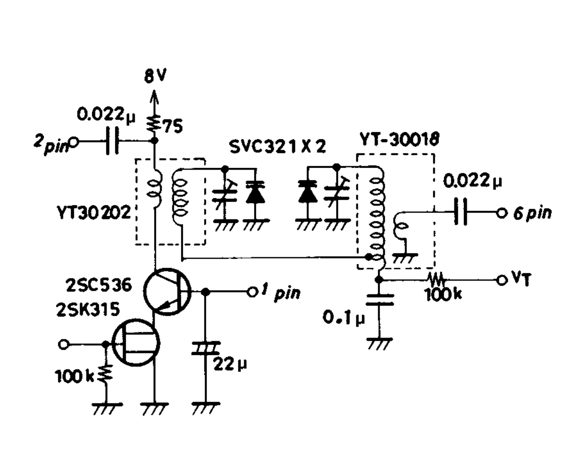


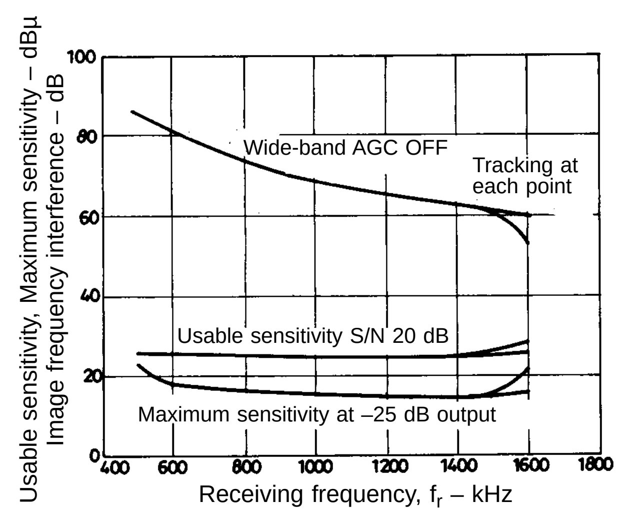

11. When using LW (approximately 50°C or greater), additionally connect a resistor of 27 kΩ across pins 18 and 19 against increase in local oscillation level. When using MW, no additional resistor is required.

12. Improvement in image frequency interference
    Change the RF double-tuning coil as follows, and the image frequency interference becomes 63 dB at $f_r$ = 1400 kHz. (Q of the tuning circuit must not be decreased with resistor 100 kΩ.)

Continued on next page.

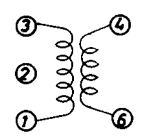
Continued from preceding page.




Unit (resistance: Ω, capacitance: F)

Specification for coil



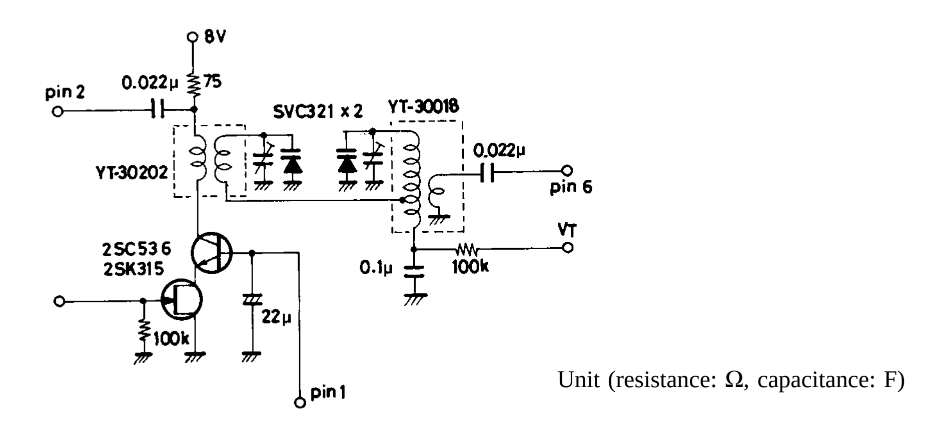

| | YT-30202(Mitsumi) |
|---|---|
| 1-3 | 84T |
| 4-6 | 17T |

2157-2239-649 (Sumida)
7BRS-9286A (Toko)

13. The variations (especially in case of small coupling coefficient) in the oscilation coil may cause a parasitic oscillation of approximately 100 MHz to occur at the local oscillation buffer output (pin 20) at low temperatures. In this case, connect a capacitor of 30 pF or greater across pin 20 and GND. (When the oscillation coil is used with no tap, no problem arises.)

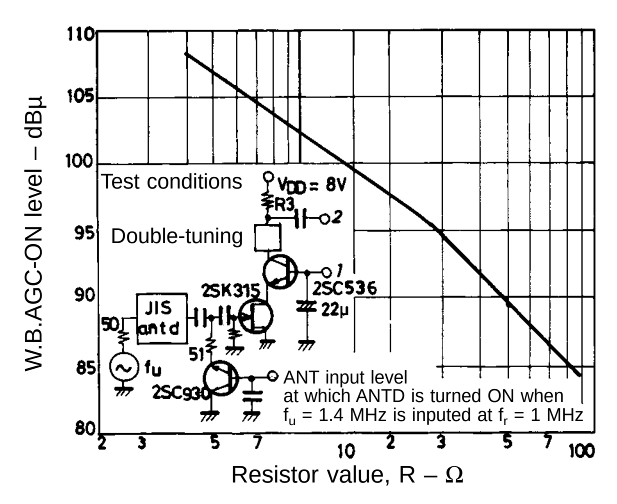
14. The recommended double-tuning circuit has a loose coupling at 2T. Therefore, the change in the total number of turns may affect the coupling coefficient subtly, causing a tight coupling and making the selectivity characteristic double-humped. Especially for a receiving band of 1400 kHz or more, the tracking method may affect the band characteristic of sensitivity and the cross modulation characteristic considerably. When making a design, check to see if critical coupling occurs or not.

15. Sensitivity difference at 600 kHz or less
In the application circuit configuration shown below, the bypass capacitor in the position where the tuning voltage is applied and coupling L for double-tuning may cause an antiresonance point of 400 kHz to 600 kHz depending on the variations in the coil, varactor diode, etc. The value of the bypass must be 0.047 μF or greater. The recommended value is 0.1 μF.

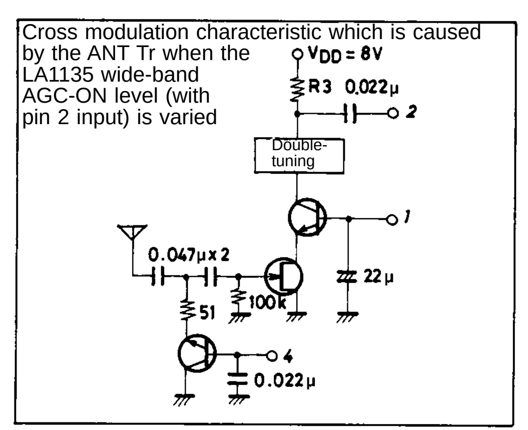



Unit (resistance: Ω, capacitance: F)

16. Measure against suppression of sensitivity in the presence of an undesired signal of high strength
(Sample application where two PIN diodes are used in the antenna damping circuit)
The LA1135 contains the wide-band AGC circuit (wide-band AGC with pin 2 input) against cross modulation which occurs because an undesired signal of high strength distorts the FET input. The AGC = ON level depends on the value of external resistor R3 as shown below.




When a nonlinear element, such as transistor, is used for antenna damping, cross modulation which occurs when the transistor is turned ON is as shown below.



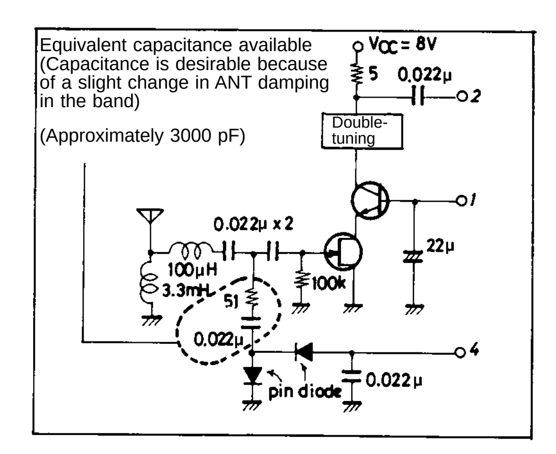

Unit (resistence: Ω, capacitance: F)

**Cross Modulation Characteristics**

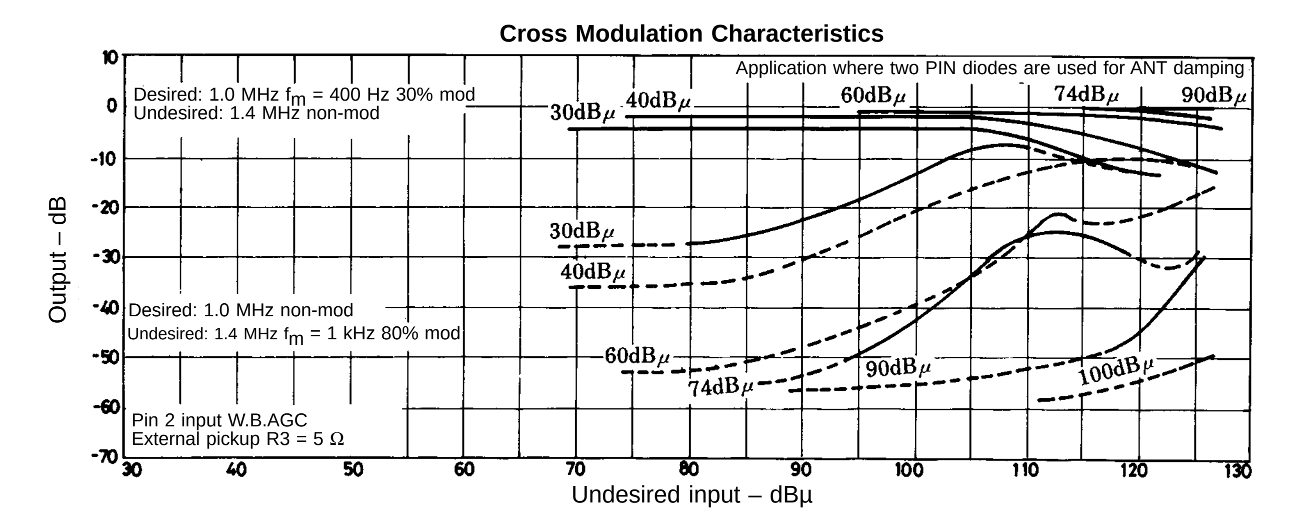
Desired:1.0 MHz 400 Hz 30% mod 74 dBμ
Undesired: 1.4 MHz non-mod
20Ω
51Ω
Wide-band AGC (pin 2 input)75Ω
Desired: 1.0 MHz 400 Hz non-mod 74 dBμ
Undesired: 1.4 MHz 1 kHz 80% mod
20Ω
pick up R3
51Ω
75Ω
Cross modulation which occurs when the transistor for ANT damping is turned ON
Output – dB
-0, -10, -20, -30, -40, -50, -60, -70
50, 60, 70, 80, 90, 100, 110, 120, 130
Undesired input – dBμ

The dynamic range of the FET input covers up to approximately 110 dBμ of antenna input, but the AGC-ON level must be set lower because of the bad effect shown above.
Therefore, there are some cases where it is difficult to receive a desired signal of low strength in the presence of an an undesired signal of high strength. To solve this problem, a sample application circuit where two PIN diodes with good linearity are used for antenna damping and its cross modulation characteristic are shown below.

Sample Application Circuit where two PIN diodes are used for ANT damping




Unit (resistance: Ω, capacitance: F)

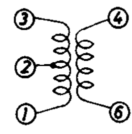



17. For details of the LA1135 wide-band AGC, refer to Technical Data No.79.

## External Parts

(1) RF double-tuning coil

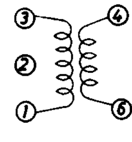
Primary



L1-3 = 224μH

| | YT-30020 (Mitsumi) | 2157-2239-518A (Sumida) | 7BRS-8934A (Toko) |
|---|---|---|---|
| 1–2 | 2T | 2T | 2T |
| 6–4 | 37T | 40T | 35T |
| 2–3 | 82T | 90T | 75T |

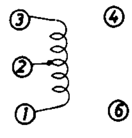
Secondary



L1-3 = 224μH

| | YT-30018 (Mitsumi) | 2157-2239-517A (Sumida) | 7BRS-8932A (Toko) |
|---|---|---|---|
| 1–2 | 2T | 2T | 2T |
| 6–4 | 15T | 16T | 14T |
| 2–3 | 82T | 90T | 75T |

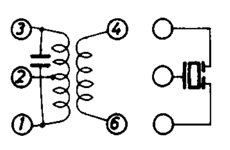
(2) OSC coil



L1-3 = 118μH

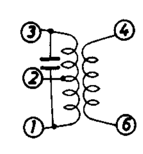
| | YT-30008 (Mitsumi) | 2157-2239-516 (Sumida) | 7BR-5941Y (Toko) |
|---|---|---|---|
| 1–2 | 29T | 34T | 29T |
| 2–3 | 29T | 35T | 29T |

(3) IFT (I)



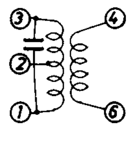
| | CFMA-027 (Toko) |
|---|---|
| 1–2 | 69T |
| 2–3 | 77T |
| 4–6 | 14T |
| Center frequency 450 kHz<br>Qu = 115 ± 20%<br>Tuning capacitance 180 pF | |

High selectivity type



| | YT-30042 (Mitsumi) +SFP450H (Murata) |
|---|---|
| 1–2 | 49T |
| 4–6 | 27T |
| 2–3 | 103T |
| Center frequency 450 kHz<br>Qu = 45 ± 20%<br>Tuning capacitance 180 pF | |

(4) IFT (II)




| | YT-30007 (Mitsumi) | 4140-1289-164 (Sumida) | 7MC-6272N (Toko) |
|---|---|---|---|
| 1–2 | 115T | 111T | 110T |
| 4–6 | 6T | 6T | 6T |
| 2–3 | 37T | 36T | 36T |
| | Center frequency 455 kHz, Qu = 110% Tuning capacitance 180 pF | Center frequency 455 kHz Qu = 110% Tuning capacitance 180 pF | Center frequency 455 kHz, Qu = 110% Tuning capacitance 180 pF |

(5) Varactor diode: SVC321

(6) FET at RF stage: 2SK315 F, G
2SK427 T, U

(7) Transistor for AGC
FET AGC: 2SC536 F, G
ANT damping: 2SC930 E

(8) Narrow-band resonator BFU450CN Murata

**Overall Characteristics**

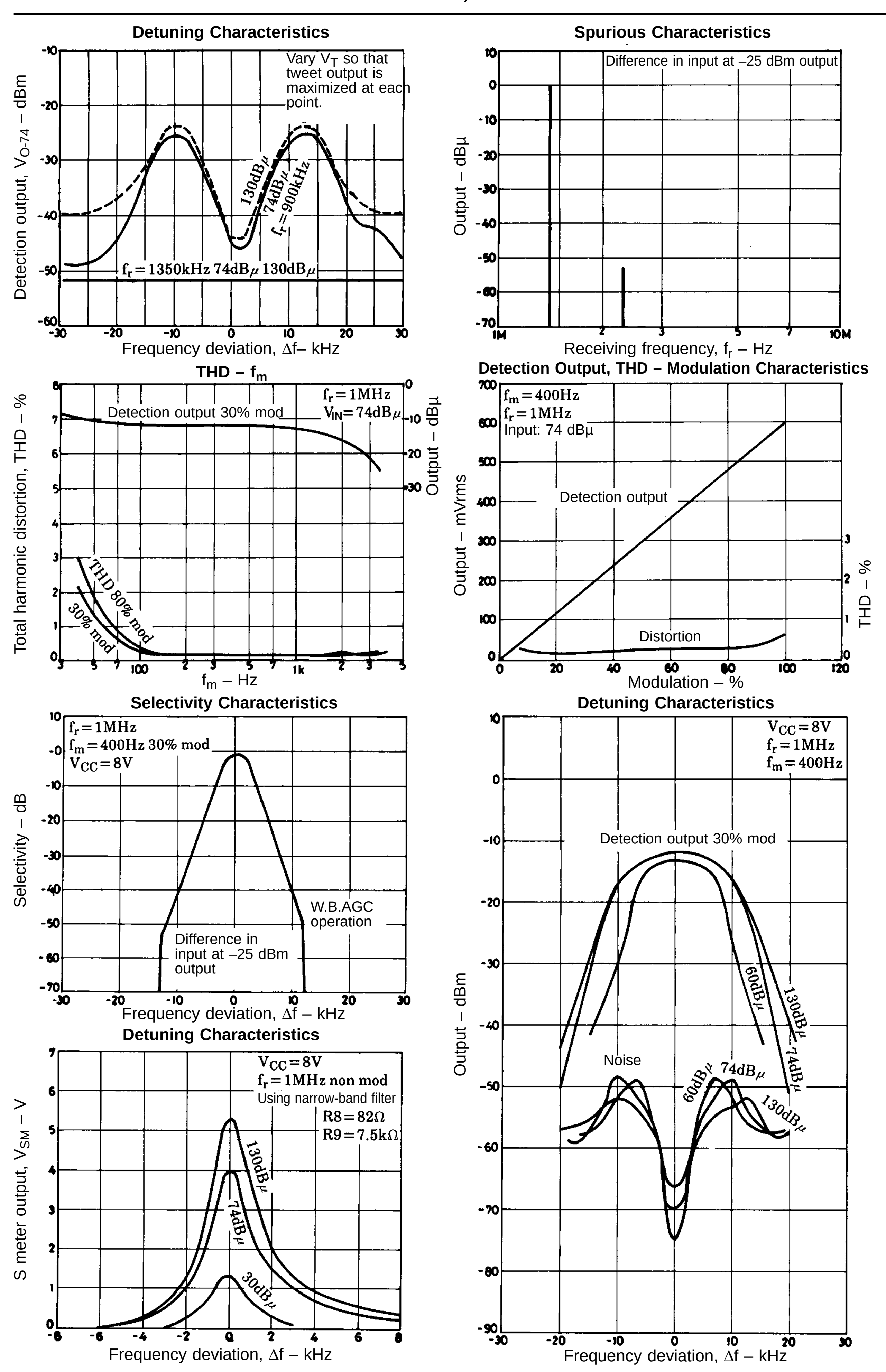
$f_r$ = 1MHz
$f_m$ = 400Hz
$V_{CC}$ = 8V
Detection output at 30% mod
$V_{SM}$
Noise
THD
30% mod
80% mod
Output – dBm
$V_{SM}$ – V
THD – %
Input voltage – dBμ

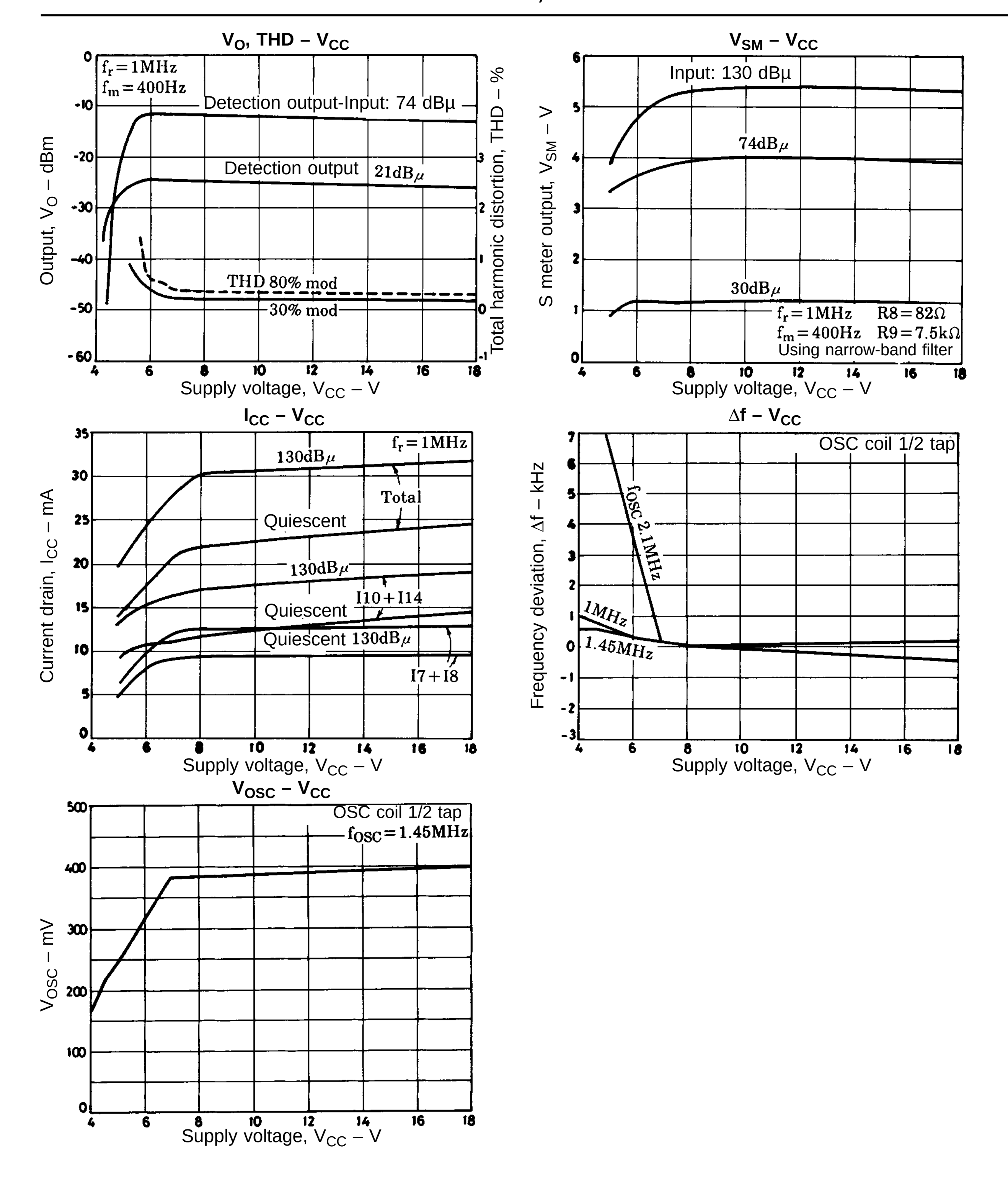
**Tweet Input Characteristics**

Signal characteristic
$f_r$ = 900 kHz $f_m$ = 400 Hz 30% mod
Tweet Max
Complete tuning (Beat max. at 900 kHz tuning)
Complete tuning (Zero beat)
Output – dBμ
ANT input – dBμ

**Band Characteristics**

$V_{CC}$ = 8V
Tracking at each point
IF interference
Wide-band AGC cutoff
Image frequency interference
$S/N_{-74}$
Input at 20 dB S/N
Input at –25 dBm output
$V_{OSC}$
THD 74
THD 130
M.S., Q.S. – dBμ
IF interference, image frequency interference, $S/N_{-74}$ – dB
Total harmonic distortion, THD – %
Receiving frequency, $f_r$ – kHz


Detuning Characteristics
Vary VT so that tweet output is maximized at each point.
130dBμ
74dBμ
fr = 900kHz
fr = 1350kHz 74dBμ 130dBμ
Detection output, VO-74 – dBm
Frequency deviation, Δf– kHz
Spurious Characteristics
Difference in input at –25 dBm output
Output – dBμ
Receiving frequency, fr – Hz
THD – fm
fr = 1MHz
VIN = 74dBμ
Detection output 30% mod
THD 80% mod
30% mod
Total harmonic distortion, THD – %
Output – dBμ
fm – Hz
Detection Output, THD – Modulation Characteristics
fm = 400Hz
fr = 1MHz
Input: 74 dBμ
Detection output
Distortion
Output – mVrms
THD – %
Modulation – %
Selectivity Characteristics
fr = 1MHz
fm = 400Hz 30% mod
VCC = 8V
W.B.AGC operation
Difference in input at –25 dBm output
Selectivity – dB
Frequency deviation, Δf – kHz
Detuning Characteristics
VCC = 8V
fr = 1MHz
fm = 400Hz
Detection output 30% mod
60dBμ
130dBμ
74dBμ
Noise
60dBμ
74dBμ
130dBμ
Output – dBm
Frequency deviation, Δf – kHz
Detuning Characteristics
VCC = 8V
fr = 1MHz non mod
Using narrow-band filter
R8 = 82Ω
R9 = 7.5kΩ
130dBμ
74dBμ
30dBμ
S meter output, VSM – V
Frequency deviation, Δf – kHz


VO, THD – VCC
fr = 1MHz
fm = 400Hz
Detection output-Input: 74 dBµ
Detection output 21dBµ
THD 80% mod
30% mod
Output, VO – dBm
Total harmonic distortion, THD – %
Supply voltage, VCC – V
VSM – VCC
Input: 130 dBµ
74dBµ
30dBµ
fr = 1MHz R8 = 82Ω
fm = 400Hz R9 = 7.5kΩ
Using narrow-band filter
S meter output, VSM – V
Supply voltage, VCC – V
ICC – VCC
130dBµ
fr = 1MHz
Total
Quiescent
130dBµ
I10 + I14
Quiescent
Quiescent 130dBµ
I7 + I8
Current drain, ICC – mA
Supply voltage, VCC – V
Δf – VCC
OSC coil 1/2 tap
fOSC 2.1MHz
1MHz
1.45MHz
Frequency deviation, Δf – kHz
Supply voltage, VCC – V
VOSC – VCC
OSC coil 1/2 tap
fOSC = 1.45MHz
VOSC – mV
Supply voltage, VCC – V

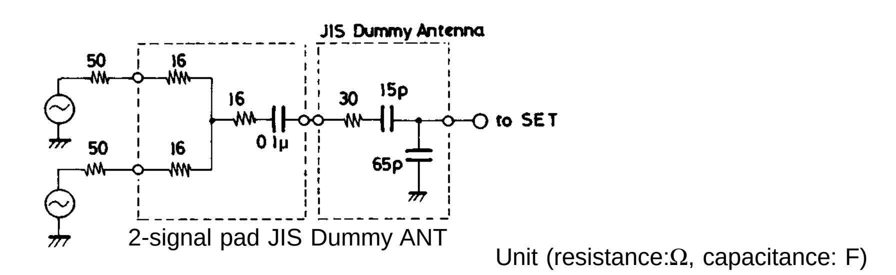
**Temperature Characteristics**

S meter output, $V_{SM-130}$, $V_{SM-47}$ – V
$V_{SM}$ = 1V input – dBµ
ANT D ON input – dBµ
W.B.AGC ON input – dBµ
$V_{AGC-0}$ – V
Current drain, $I_{CC}$ – mA
$V_{SM}$ = 1 V input
$V_{SM-130}$
$V_{SM-74}$
$V_{SM-30}$
W.B.AGC on
$V_{AGC-0}$
ANT D ON
$I_{CC-130}$
$I_{CC-0}$
Ambient temperature, Ta – °C

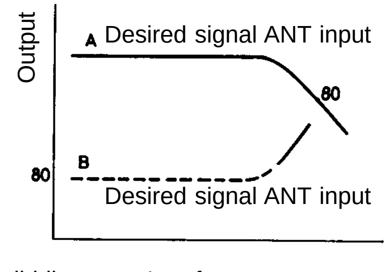
**Temperature Characteristics**

Usable sensitivity (Input at 20 dB S/N)
Usable sensitivity, Q.S. – dBµ
Maximum sensitivity, MS – dBµ
$V_{O-74}$ – dBm
S/N_-74 – dB
Total harmonic distortion, THD – %
$V_{OSC}$ – mVrms
QS
MS
S/N-74
$V_{O-74}$
$V_{OSC}$
THD-130
THD-74
Ambient temperature, Ta – °C

## Cross Modulation Characteristics Testing Method



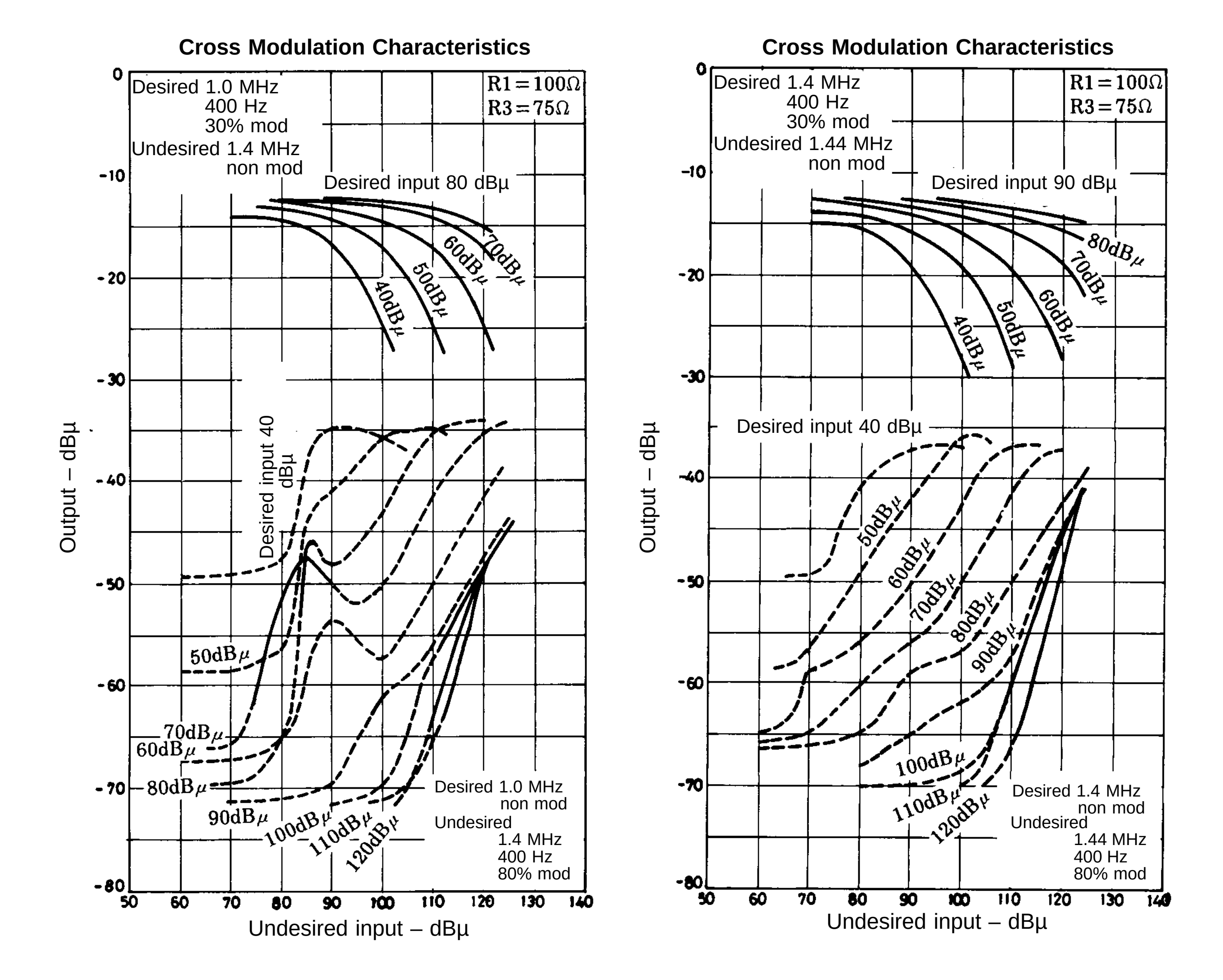

Unit (resistance:Ω, capacitance: F)




Solid line —— Interference
Dotted line ---- No interference

A: Desired signal 80 dBµ 400 Hz 30% mod. The strength of an undesired signal (non-mod) causes the desired signal to be suppressed.

B: Desired signal 80 dBµ non-mod. The strength of an undesired signal (400 Hz 80% mod) causes interference to occur.


Cross Modulation Characteristics
Desired 1.0 MHz
400 Hz
30% mod
Undesired 1.4 MHz
non mod
R1 = 100Ω
R3 = 75Ω
Desired input 80 dBμ
40dBμ
50dBμ
60dBμ
70dBμ
Desired input 40 dBμ
50dBμ
60dBμ
70dBμ
80dBμ
90dBμ
100dBμ
110dBμ
120dBμ
Desired 1.0 MHz
non mod
Undesired
1.4 MHz
400 Hz
80% mod
Output – dBμ
Undesired input – dBμ
Cross Modulation Characteristics
Desired 1.4 MHz
400 Hz
30% mod
Undesired 1.44 MHz
non mod
R1 = 100Ω
R3 = 75Ω
Desired input 90 dBμ
40dBμ
50dBμ
60dBμ
70dBμ
80dBμ
Desired input 40 dBμ
50dBμ
60dBμ
70dBμ
80dBμ
90dBμ
100dBμ
110dBμ
120dBμ
Desired 1.4 MHz
non mod
Undesired
1.44 MHz
400 Hz
80% mod
Output – dBμ
Undesired input – dBμ

## Specification for LA1135 loop ANT

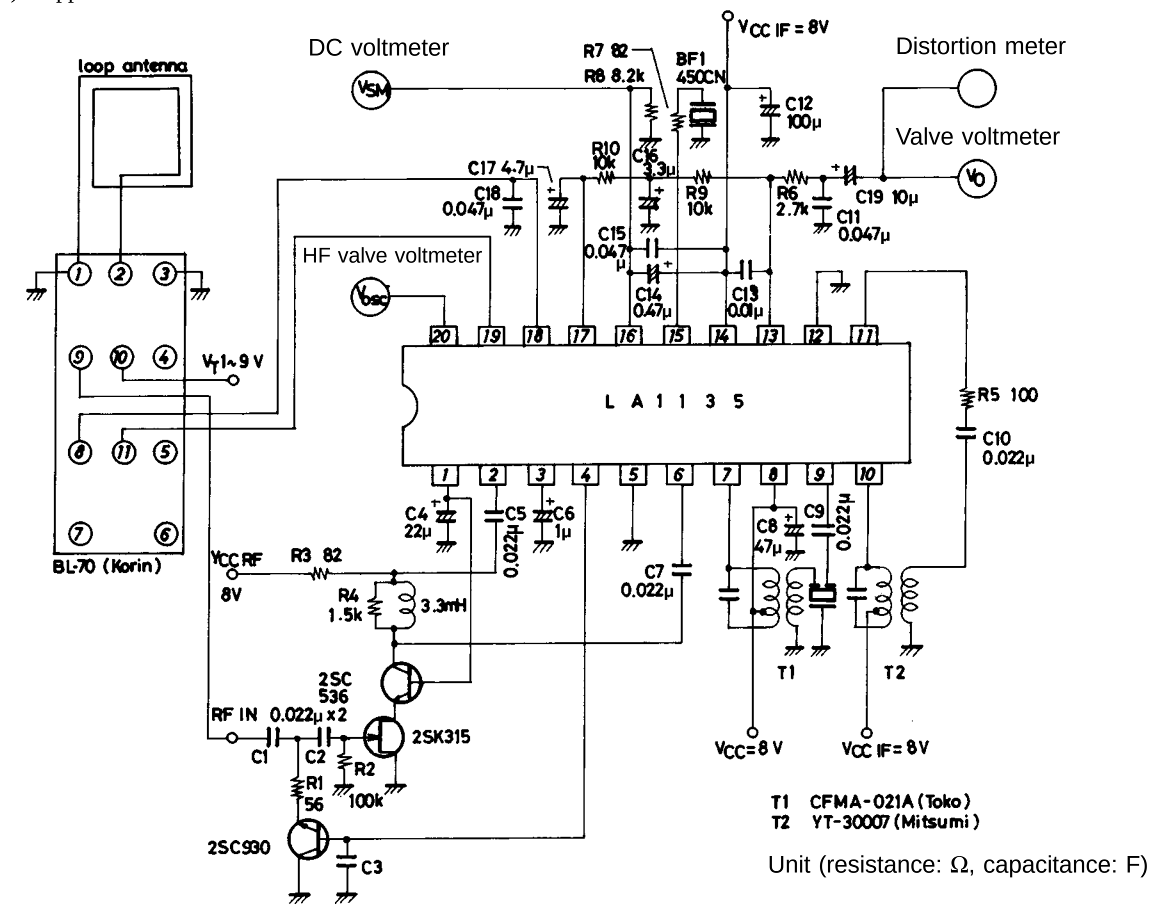
(1) Features of specification for LA1135 loop ANT

1) Excellent high-input characteristic

The antena damping circuit prevents the antena circuit from being magnetic-saturated, which results in worsened characteristic, at a high input.

2) Excellent cross modulation characteristic

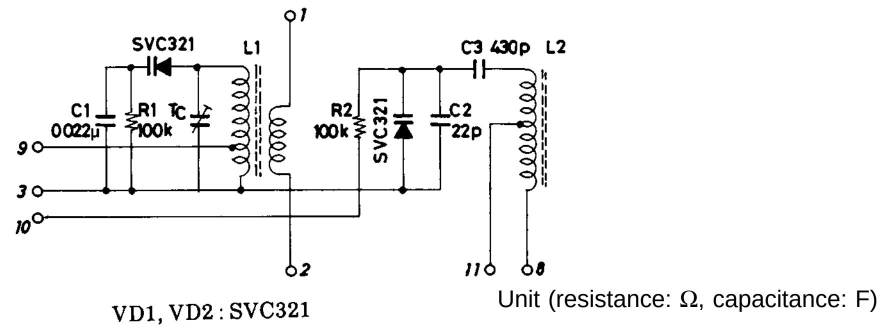
(2) Application circuit




Unit (resistance: Ω, capacitance: F)

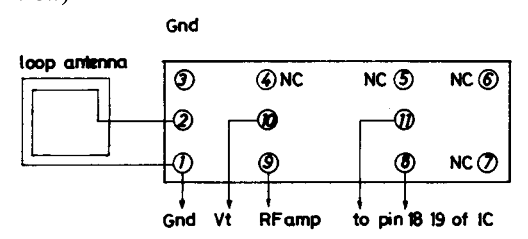
(3) Circuit configuration and connection

3-1 Circuit configuration




Unit (resistance: Ω, capacitance: F)

3-2 Connection (bottom view)



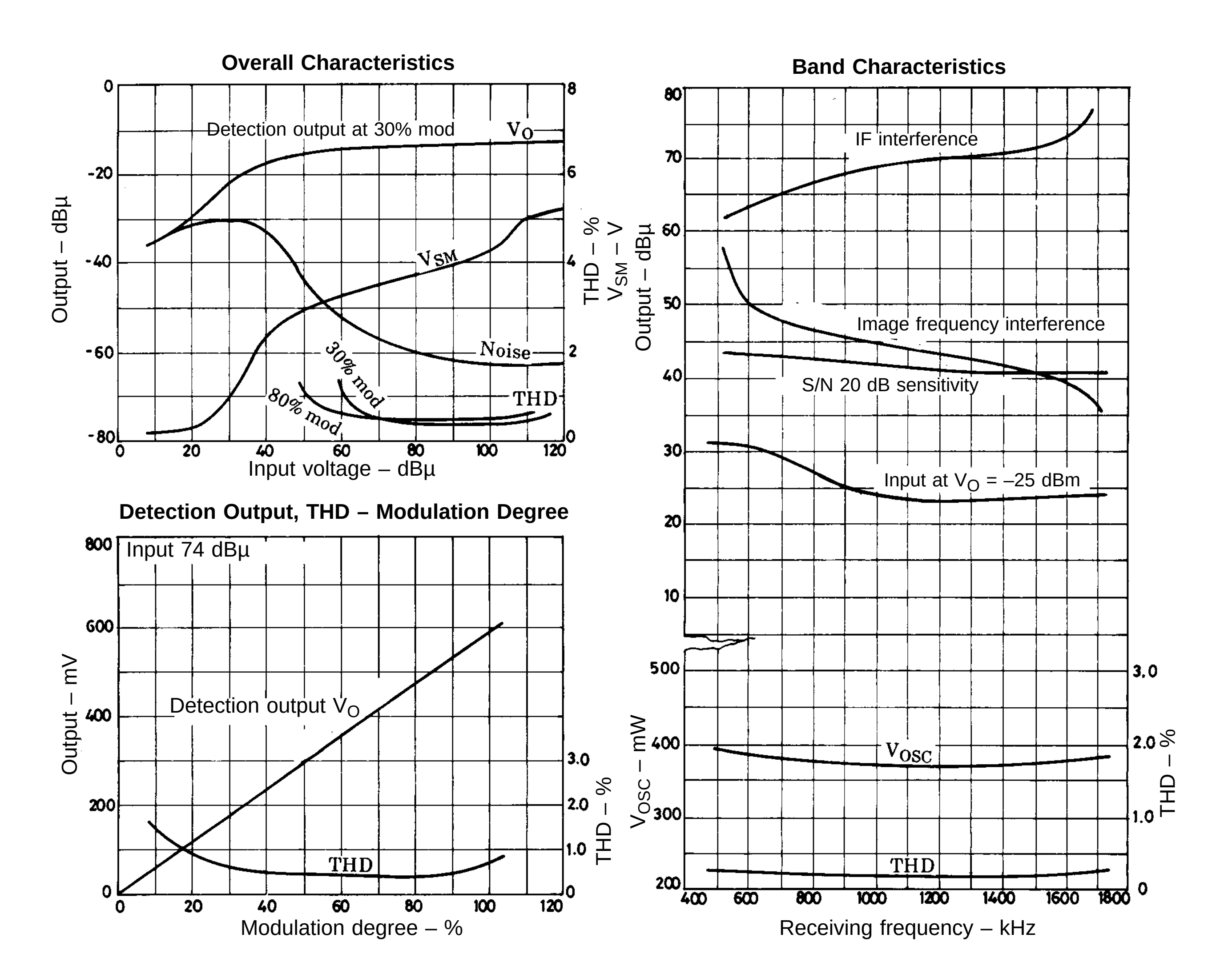
3-3 Pin name

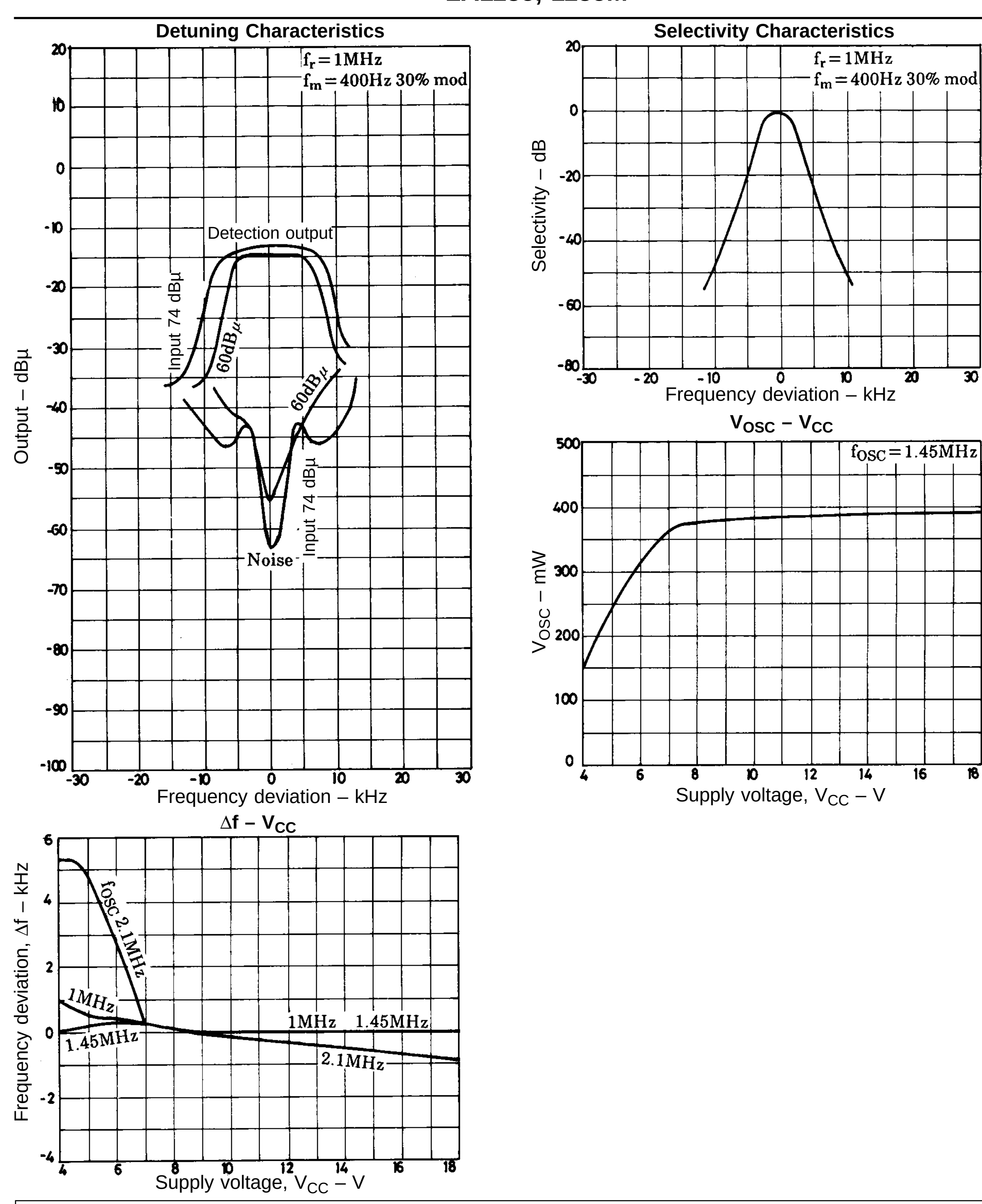
| Pin No. | Pin Name |
|---|---|
| 1 | Loop ANT |
| 2 | Loop ANT |
| 3 | RF AMP GND side |
| 4 | NC |
| 5 | NC |

| Pin No. | Pin Name |
|---|---|
| 6 | NC |
| 7 | NC |
| 8 | Local OSC |
| 9 | RF output |
| 10 | Tuning voltage |
| 11 | Local OSC |

(4) Specification

| | |
|---|---|
| Receiving frequency band | MW BAND |
| Tuning voltage | 1 to 9 V |
| Loop ANT | 42579719100 (LA-1500), 4257976000 (LA-100A) (Korin) |
| IC | LA1135 |




Detuning Characteristics
fr = 1MHz
fm = 400Hz 30% mod
Detection output
Input 74 dBμ
60dBμ
60dBμ
Input 74 dBμ
Noise
Output – dBμ
Frequency deviation – kHz
Selectivity Characteristics
fr = 1MHz
fm = 400Hz 30% mod
Selectivity – dB
Frequency deviation – kHz
VOSC – VCC
fOSC = 1.45MHz
VOSC – mW
Supply voltage, VCC – V
Δf – VCC
fosc 2.1MHz
1MHz
1.45MHz
1MHz 1.45MHz
2.1MHz
Frequency deviation, Δf – kHz
Supply voltage, VCC – V